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Analysis of the opportunities and challenges of solar water heating system (SWHS) in India: Estimates from the energy audit surveys & review

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ABSTRACT

A solar water heating system (SWHS) is a device that makes available the thermal energy of the incident solar radiation for use in various water heating applications. SWHS largely depends on the performance of the collector's efficiency at capturing the incident solar radiation and transferring it to the water. With today's SWHS, water can be heated up to temperatures of 60–80 °C. Heated water is collected in a tank insulated to prevent heat loss. Circulation of water from the tank through the collectors and back to the tank continues automatically due to the thermosiphon principle. The hot water generated finds many end-use applications in domestic, commercial, and industrial sectors. India has the highest energy intensities in Asia. Very little investment and priority are being given to increase of the efficiency. On the other hand, the India has a high potential for developing energy production from renewable energy sources (RES): solar, water, wind and biomass. However, these potentials are not studied and exploited enough and the present situation for their utilization is not so good. Although energy is a critical foundation for economic growth and social progress of any country, there are many constraints for RES development in all of them (political, technological, financial, legislative, educational, etc.). Obviously, defining development strategies and new support measures is necessary since renewable energy sources can make an important contribution to the regional energy supply and security. The main purpose of this paper is to explore the solar water heating system (opportunities) in India.

Contents

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1. Introduction

The sun is the planet's most powerful source of energy and also the most unused source of energy by humans. Solar power is a clean, environmentally friendly source of energy. It is renewable meaning it is impossible to consume the energy at a faster rate than it takes to replenish it for future users. There are no toxic byproducts or emissions. Sun Heat is an effective system that harnesses the sun's energy for family water heating needs.

Solar water heating systems are in high demand. Typically 30–40% of a family's electricity bill is devoted to devoted water. Sun Heat's system can save the individual family from 70% to 90% of the total amount spent on the electricity used for heating water. The system generally meets all of the summer time heating needs. During times of decreased sunlight, the system will preheat the water then bring it up to temperature by the conventional water heating system already in place.

The first serious attempts to deploy the technology were made with the formation of Department of Non-Conventional Energy Sources (DNES) in 1982, though the history of research and pilot-demonstration go back to 1960s. The total installed collector area increased from 119,000 m^2 in 1989 to 525,000 m^2 in 2001 [1] and to estimated 3.1 million m^2 by December 2009 [2].

- 1995–2000: the average annual growth during this period was 8.2%. A study reported that in 2001, almost 80% of the SWH installations were in the commercial and industrial sectors.
- 2001–2004: the average annual growth rate during this period was 20.6%. The market for residential systems became predominant.
- 2004–2008: the average annual growth rate during this period was 24.6% [5].

The Commercial and Institutional Building Energy Use Survey (CIBEUS) is intended to provide government, utility providers, building managers and academic researchers with pertinent information on energy use characteristics to aid them in decision-making and consideration of policy issues.

1.1. Indian market

The estimated brake up of usage of SWHS installations are as follows: (Graph 1)

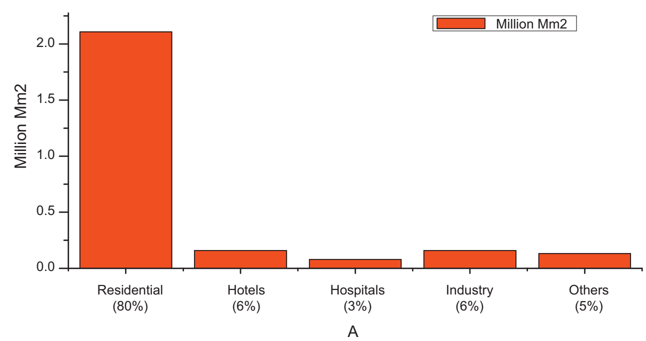
The sale during 2009 is estimated at 0.55 million m^2. The cumulative installation during 1995–2000 was 8.23%. It spurted to 20.6% during 2000–04 and further to 24.6% during 2004–08, denoting overall of 16.8% over 1995–2008.

The following explains demand upsurge in recent years.

- Growth in new urban housing, rising disposable income, increased propensity for consumer durables [3].
- Arrival of ETC & improvements in supply chain.
- Drastically increase of energy price.
- Policy initiatives.

Table 1
SWH potential under realistic scenario (cumulative million m^2).

Year	2010	2013	2017	2022
Residential	2.58	4.25	7.68	15.74
Hotels	0.19	0.35	0.61	0.97
Hospitals	0.10	0.17	0.27	0.43
Others	0.19	0.33	0.57	1.05
Total	3.24	5.37	9.52	18.70



Graph 1. Estimated breakup: functional SWH installations till 2009. It is assumed that 85% of the installed SWH are functional.

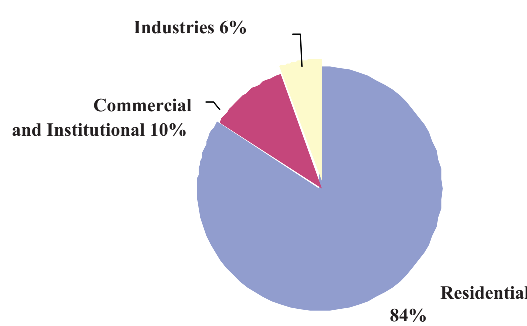


Fig. 1. Percentage-share of sectors in SWH installations 2022.

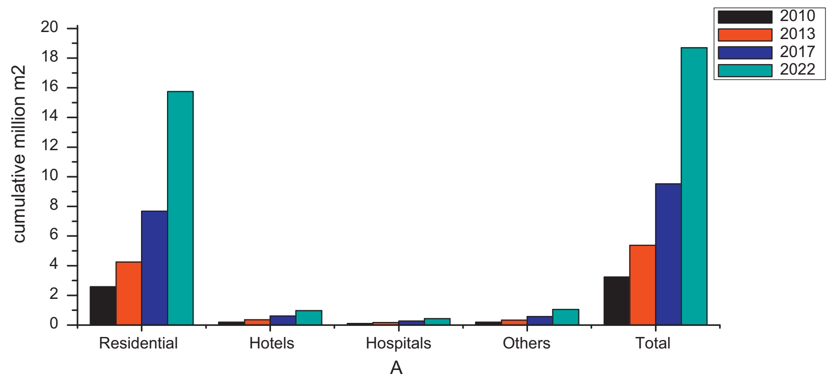
1.2. SWH potential projection

- Under realistic scenario, estimate demand as follows.

Residential sector would remain the largest sector and would contribute to 84% of the cumulative installations [4] (Graph 2 and Table 1).

Fig. 1 explains the percentage share of various sectors in solar water heating systems installations by 2022.

The schematic diagram of the SWHS explains the working principle and installation arrangement shown in Fig. 2.



Graph 2. Graphical representation of SWH potential.

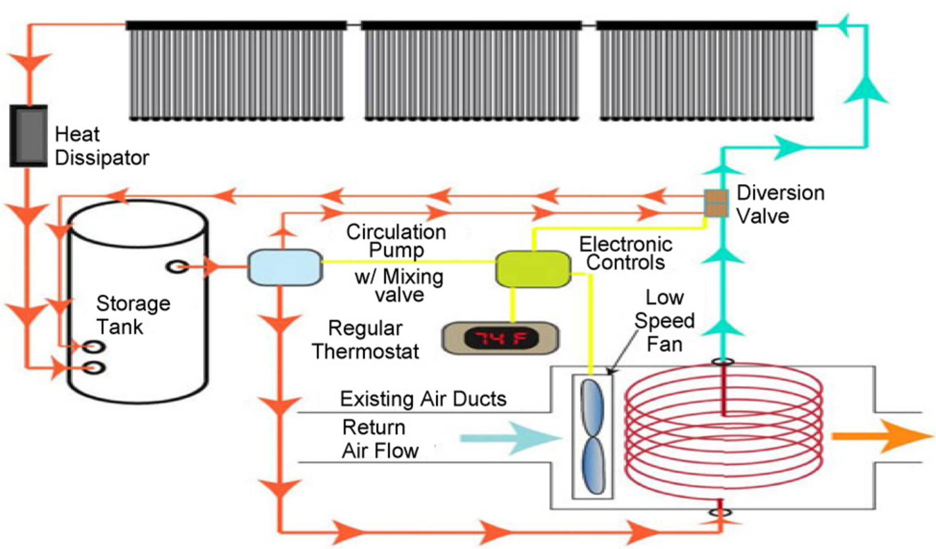


Fig. 2. Schematic diagram of the SWH system.

2. Methodology

2.1. Phase I: secondary information collection & planning of survey

In this phase, secondary information on solar water heating sector in India was collected. This information consisted of information on manufacturers, products, policies, barriers and markets.

This information was collected through literature survey with stakeholders. The collected information was used for planning of survey (phase II) of the study.

2.2. Phase II: survey (primary data collection)

The primary purpose of the survey was to collect information on:

- Hot water demand (present as well as growth trends).
- Fuel/energy source/technology used.
- Current status of solar water heater markets.
- Local policies and their enforcement.
- Gain insights into technical issues that are relevant for application of SWH (water quality, resource available, space availability, etc.).
- Case-studies on previous experiences of SWH applications and profile of the users.
- Awareness and users perception and feedback about SWH.

2.3. Phase III: assessment of market potential

The work under this phase consisted of:

- An appreciation of sector-level issues concerning installation of SWH and implications of these in terms of SWH market prospects. This is based on the primary survey inputs.
- Development of hot water requirement norms based on literature survey and primary survey.
- Putting together a full picture of existing stock for different sectors in India and expected growth until 2020.
- Clarifying the present base of SWH installations in the sector and outlining the alternative scenarios for demand buildup.
- SWH installation projection under alternative scenarios till 2020.

3. Literature survey on SWH potential in India

In India, very little published information exists on the SWH markets. In recent years, two research studies have presented methodologies for the assessment of SWH potential.

Chandrasekar and Kandpal have presented a methodology to estimate the potential number of households that can use SWH systems. The methodology establishes a relationship between the seasonal and diurnal variations in ambient temperature at a place

Table 2
Capacity addition target under JNNSM.

Details	100 LPD 60 °C	200 LPD 60 °C	300 LPD 60 °C	500 LPD 60 °C
Suitable for no of persons	4–6	8–10	12–14	20–25
No of bathroom	2 BR + 1 KT	3 BR + 1 KT	4 BR + 2 KT	7 BR + 3 KT
No of panels	1	2	3	4
Electricity saved/month	120 Units	240 Units	360 Units	600 Units

Source: JNNSM document, MNRE.

and the need of hot water for bathing. This has been used to estimate the expected capacity utilization of SWH for different locations in the country [11]. The income levels of the households directly affect their capacity to purchase SWH. Using the income distribution of households in the country, the capital cost of typical SWH, and the rate of interest on the loans provided to the users to purchase SWH, the potential number of households who can use SWH have been estimated. In one of the examples presented in the paper, it is estimated that 45 million households in India can use SWH. This translates into a potential of 90 million m^2 of SWH in the residential sector.

Pillai and Banerjee have presented a methodology for potential estimation of SWH in an area taking into consideration the factors affecting adoption at the end use level (micro-level factors) and factors that affect the aggregate market (macro-level factors). The methodology can be used to estimate the potential for the individual sectors and also for the target area as a whole [12]. The end use sectors considered are residential, hospitals, nursing homes and hotels. The estimated technical potential and market potential are 1700 m^2 and 350 m^2 of collector area, respectively.

The SWH installations in India are distributed across the following market-segments.

- Households (residential sector) – Urban and Rural.
- Commercial and institutional buildings e.g. hotels, hospitals, hostels, religious complexes, etc.
- Industries.

4. Households

SWH owners as well as non-owners, the objective was to get an understanding of consumption of hot water, purpose of water-heating, consumption pattern through the year and present arrangement for water-heating in respect of SWH owners, looked into SWH experience in terms of hot water availability throughout the year, specific problems encountered, SWH acquisition process, installation process and after-sale support process.

In respect of non-owners, the focus was on deciphering levels of perception, awareness and exposure to SWH. While collected information on the basic profile – economic status, family size – of the respondents (Fig. 3 and Table 2).

5. Hotels: 4 star and above: 150 LPD/room, 3 star: 125 LPD/room, 2 star and below: 50 LPD/room

For hotels and guesthouse, in addition to issues cited earlier, the salient points of enquiry were

- Present fuel.
- Purposes of water-heating – bathroom, kitchen, other uses.
- Roof suitability and availability for SWH.
- Soft term loan/incentives in case of SWH owners.

Table 3
Hot water demand.

Usage for	Consumption
Bathing	15 l/person/bath
Shower bath	25 l/person/bath
Tub bath	35–50 l/person/bath
Cooking	5 l/person/day
Washing clothes	10 l/person/day
Washing utensils	5 l/person/meal
Making tea/coffee	150 ml/person/cup

Consumption figures may vary, depending on the lifestyle, age, habits, and weather conditions.

6. Initial goals of the survey of commercial and institutional buildings

Solar water heaters can be used effectively in several commercial applications like hotels, hospitals, clinics and old age homes. Although the hot water demands here may be higher than residential, the increased roof area of these buildings allows for more collectors to be installed. Efficiency figures comparable to those of the residential sector can be achieved, as the relative cost of these systems is cheaper than for residential systems. Solar water heaters are not suited to replace boilers and other high temperature water apparatus in industry. However they can be used for preheating purposes, so that at least a percentage of the heating operation draws on solar, rather than carbon-based, energy.

The Commercial and Institutional Building Energy Use Survey (CIBEUS) was implemented with an aim to serve the purposes of a wide variety of stakeholders. Among the stakeholders considered in the design and implementation of the survey were various levels of government, utility providers, building managers, and academic researchers.

It was originally envisioned that the survey data might, among other things, provide information that would enable survey users to:

1. Understand energy consumption and energy efficiency characteristics of commercial and institutional buildings in India.
2. Identify ways of decreasing energy consumption and costs in commercial and institutional buildings.
3. Assess the fulfillment of greenhouse gas emission commitments by providing baseline information regarding fuel use in commercial and institutional buildings.

Hot water demand can be assumed as follows: (Table 3)

Some indicative benchmark numbers that are available for estimation of solar water heating requirement for various applications are as follows:

7. Hospitals and hostels

The approach was identical to the one for hotels and guesthouses. The usage of the hot water is as follow:

- Hospitals: 30 LPD/bed for government/private hospitals, 190 LPD/bed for multi specialty hospitals.
- Hostels: 30 LPD/student.

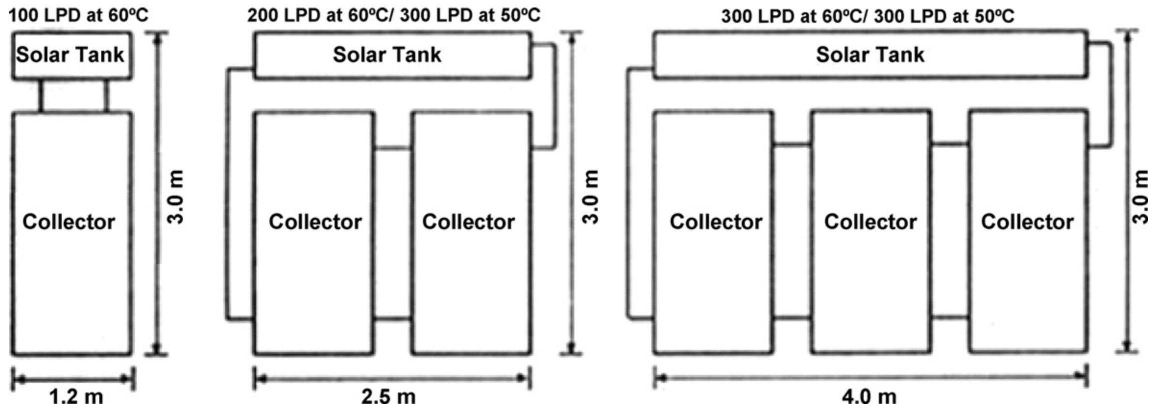


Fig. 3. Block diagram of the SWH system.

The total hot water demand can be estimated as 30–35 LPD and hence 6 beds would require a minimum of 180–210 LPD (say 200 LPD) instead of 100 LPD specified in the current byelaw. The current byelaw provision shall meet 50% of the water heating requirement.

Similarly, for industrial canteens, applying the above, the hot water demand per worker can be estimated as follows:

- For cooking = 5 l/person/day.
- For washing utensils = 5 l/person/meal.

Hence per person requirement is about 10 LPD and hence one 100 LPD is required per 10 workers, in place of 50 workers. The current byelaw provision would thus meet 20% of the hot water need for this application. The apartment blocks those have dwelling units lower than 200 m^2 should also be covered by byelaw and provision for solar water heating system should be mandated. In case of apartment buildings, the available roof area could determine the capacity of solar water heating systems to be provided.

8. Solar water heaters in India

UNDP-GEF global solar water heater project is aimed at further accelerating the market development of solar water heating and facilitating the installation of 5 million m^2 of installed collector area by 2012 [6]. Solar water heaters are also an integral part of the recently announced Jawaharlal Nehru National Solar Mission (JNNSM) of Government of India. The Mission targets to have 20 million m^2 of Solar Water.

8.1. India's policies for SWHS and the Jawaharlal Nehru National Solar Mission (JNNSM)

The central government, through Ministry of New and Renewable Energy (MNRE) provides soft loans/capital subsidy for installation of solar water heating systems. These loans are being provided through 34 banks/financial institutions at an interest rate of 2–5% to various categories of users. However, soft loans are available to domestic users of solar water heating systems at 0% interest rate in states falling under special category. Rebates and accelerated depreciation are also being provided to residential and industrial/commercial customers, respectively.

In a separate initiative, a model regulation/building bylaw for mandatory installation of SWHS in new buildings was circulated by the Ministry of Urban Development to all states and Union territories with a request for onward circulation to all local bodies for incorporation in their building bylaws. Necessary orders have been issued in 21 states and 98 municipal corporations/municipalities have so far amended their building bylaws. A few municipal corporations such as Thane, Amravati, Nagpur, and Durgapur are providing 6–10% rebate in the property tax for users of solar water heaters. Many of the utilities are providing rebate in electricity bills to the users as well.

Table 4
Capacity addition target under JNNSM.

	Cumulative target	Addition during the phase
Phase I (2010–13)	7 million m^2	3.45 million m^2
Phase II (2013–17)	15 million m^2	8 million m^2
Phase III (2017–22)	20 million m^2	5 million m^2

Source: JNNSM document, MNRE.

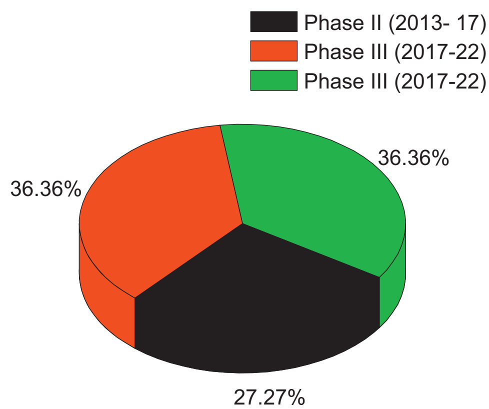
8.2. Mix of mandatory regulations, guidelines, best practices and incentives

MNRE, city Governments, builders, architects, BEE will work together to formulate and implement a mix of SWH-favoring legal/administrative mandatory regulations, guidelines and best practices for residential and non-residential buildings at least in high-potential cities. A large-number of the cities covered under the primary survey fall under the category of high-potential cities. We presume the mix of mandatory regulations and best practices will be accompanied by a financial incentive for new residential buildings. The new non-residential buildings under hotel/hospital/hostel segments will require lesser financial incentive. It is imperative that the incentive reaches most customers. Likewise, it is important that multiple incentives are largely merged into a single, powerful incentive.

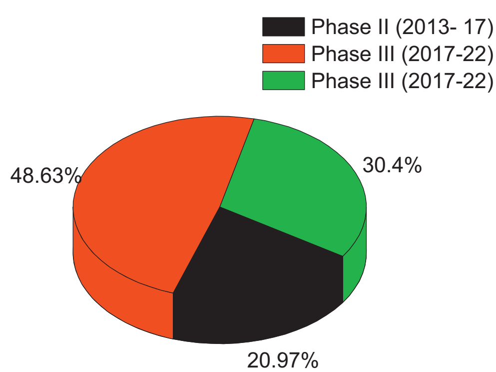
Solar water heaters are also an integral part of the NSM (National Solar Mission). It has ambitious targets to achieve – 20 million m^2 of collector area of SWHSs by the year 2022. The target set for solar water heaters is as per Table 4. The key strategies of the NSM will be to make necessary policy changes to meet this objectives, ensure the introduction of effective mechanisms for certification and rating of manufacturers of solar thermal applications, facilitate measurement and promotion of these individual devices through local agencies and power utilities, and supporting the up gradation of technologies and manufacturing capacities through soft loans, to achieve higher efficiencies and further cost reduction (Graph 3 and 4).

One of the pre-requisite is to gain a better understanding of the current solar water heater market in the country and identify sectors and geographical areas having high potential for SWH.

To achieve this ambitious target, the mission aims: (Table 5)



Graph 3. Cumulative target % in million m^2.



Graph 4. Addition during the phase % in million m^2.

Table 5
Indian scenario of solar water heating.

Indian scenario of solar water heating	
Techno-economic potential	40 million m^2
National solar mission goal	20 million m^2 by 2022, 7 million m^2 by 2013
Demand projection	5.4 million m^2 by 2013, 18.7 million m^2 by 2022
Cumulative achievement	3.52 million m^2 up to 31.03.10
Pre-project baseline	2.55 million m^2 as on 30.09.08

- To create an enabling policy framework to the deployment of 20,000 MW of solar power by 2022 [10].
- To ramp up capacity of grid-connected solar power generation to 1000 MW within three years-by 2013 and an additional 3000 MW by 2017 through the mandatory use of the renewable purchase obligation by utilities backed with a preferential tariff.
- To create favorable conditions for solar manufacturing capability, particularly solar thermal for indigenous production and market leadership.
- To promote programs for off-grid applications, reaching 2000 MW by 2022 including 20 million solar lighting systems.
- To achieve 20 million square meter solar thermal collector area by 2022.

According to the 11th five year plan, the Government of India projects a massive expansion in installed solar capacity, and aims to reduce the price of electricity generated from solar energy, to match that from fossil fuels like coal and diesel by 2030. MNRE has set up target to add 14,500 MW by 2012 [9], from new and renewable energy resources out of which 50 MW would be from solar energy [7]. India has received committed investments to the tune of US $7 Billion and additional to come in through the FDI and private sector route.

9. Factors influencing SWH market in residential sector

One of the main objectives of the primary survey was to gain a better understanding of the factors influencing market for SWHs. The main findings are summarized below:

- *Demand for hot water*: demand for hot water for bathing shows significant variations across regions. The demand for hot water not only depends on climatic factors but also depends on human behavior (which is influenced by culture and traditional practices). The survey found that apart from cold and moderate climatic regions, which show a high demand for hot water (>8 months/year) for bathing. There are certain areas in the country which do not fall under cold and moderate climate regions but exhibit high use of hot water e.g. parts of Maharashtra, Kerala, Tamil Nadu. So it does not come as a surprise that the two largest urban residential markets are Bangalore and Pune.
- *Type of house*: low-rise independent houses with clear ownership of the roof offer most favorable conditions for installation of SWH. A majority of existing SWH installations fall under this category. In recent years, SWH have been installed on multi-storey apartment buildings. Despite some well-functioning SWH systems in multi-storey apartment buildings, the general perception among stakeholders is that SWH are more suitable for independent house. Some of the apprehensions about the feasibility of a centralized solar water heating system in multi-storey buildings are related with:
- *Electricity supply situation*: electric geysers were found to be the most common water-heating device in the households. As a result, electricity shortages particularly power-cuts during morning hours influences the demand for SWH.
- *Awareness about SWH*: leaving out states like Karnataka and parts of Maharashtra which have relatively high penetration of SWH, general awareness about SWH was found to be low in rest of the country. Though people are familiar with the concept, the awareness on technologies and products was found to be very low.
- *Household income*: SWH is a product owned by affluent households. 76% of the surveyed SWH owner households owned a car and thus it can be concluded that a majority of the households owning SWH fall under the 'rich' and 'striver' categories as per affluence layers distribution based on household income by NCAER16.
- *Policy*: the highlights of the present policy environment are as follows:
  1. Several of the municipal corporations have issued orders making SWH use compulsory for new multi-storey housing and houses constructed on plots having area more than 500 sq. yards.
  2. A few of the municipal corporations are offering rebate in property tax.
  3. A few of electricity distribution companies offer rebate in monthly electricity bills.
  4. Several states offer upfront subsidy for residential systems.
  5. IREDA through banks is operating an interest subsidy scheme to offer concessional finance for installation of SWH.

The impact of policy measures is mixed. Implementation of mandatory regulations is weak across cities, if implemented rigorously it has the potential to become an important driver in market development. Upfront subsidies by states do assist in development of market in the initial stages but the process of availing subsidy is generally long and cumbersome and in the states where it is offered only a fraction of the SWH owner households are availing subsidies. Rebate on property tax is being offered by only few cities, the amount of rebate available is small; the effectiveness of this

instrument is yet to be tested. Rebate in electricity bills is a useful instrument to promote SWH, however, it is being offered in very limited number of cities. Only a few banks and financial intermediaries are putting effort in implementing IREDA interest subsidy scheme. The scheme is being implemented successfully in some pockets; however, there is a scope to improve implementation of this scheme.

10. Hotels

The major observations are as follows.

- *SWH awareness and exposure*: the awareness on SWH, among hotel owners and managers, is good across hotel standards. The owner of a budget hotel, in terms of SWH-concept and to some extent exposure, is nearly as aware as that of a General Manager of luxury hotels. Likewise, SWH installations exist across hotel standards. Thus, hotel-standard, other things being equal, is not a deterrent to readiness for SWH.
- *Poor radiation days in a year*: unlike households, hotel/guesthouses are not discouraged by cloud cover or low radiation for a few days or weeks in the year. Thus, monsoon or fog in winter in itself is not the reason for hotel/guesthouses to stay away from SWH.
- *Roof availability*: the roof-availability for SWH is an issue mainly for hotels/guesthouses which do not own the roof. The roof-ownership, in turn, is linked to the hotel-size. There is the trend, among centrally air-conditioned hotels, of setting up cooling towers, hydro equipment satellite dish antennas on the roof. Despite this trend, there remains adequate space to install SWH to meet the hot water requirement in most of such hotels. A six-storied, 200 room five-star hotel commissioned recently at Ahmedabad, has utilized 75% of its roof for the installation of other equipment, 20% of its roof space is enough to meet 100% of its hot water requirement through SWH installation. Though it should be mentioned that roof availability could be an issue in some of the high-rise (tower) hotels.
- *Present fuel use*: the hotels having a room capacity upward of 30 rooms largely utilize liquid fuel (or gaseous fuels in cities having piped natural gas supply) for water-heating. The small hotels – room capacity up to 30 rooms – rely on electricity or wood. It is attractive, from a payback period perspective, for electricity and liquid fuel dependent hotels/guest houses to adopt SWH.

11. Hospitals

The major observations are as follows:

- *SWH awareness and exposure*: the awareness on SWH, among private hospital owners, is mixed across hospital standards/size. The knowledge of owners of small private hospitals is less-favorable for – SWH climatic zones, in most instances; the knowledge is limited to existence of SWH product.
- *Poor radiation days in a year*: unlike households, hospitals are not discouraged by cloud cover or low radiation for a few days or weeks in the year. Thus, monsoon or fog in winter in itself is not the reason for private hospitals to stay away from SWH.
- *Roof availability*: for government hospitals, roof is clearly available for SWH installation. The roof in respect of private hospitals appears substantially available but the precise position is not clear. Most private hospitals having 15 patient beds upward are assumed to possess roof for SWH installation. In respect of up to 15 bed hospitals, roof availability is mixed because many of these hospitals are independent buildings with own roof. Estimate that 10–15% of private hospital beds cannot be serviced by SWH because of roof availability. The new private hospitals, regardless of size and ownership of roof, can be mandated to install SWH through working out access to the common roof, since a policy of compulsory SWH for hospital is already in vogue in principle.
- *Present fuel use*: the hospitals, barring large private hospitals – use electricity for water-heating. The cost of water-heating, therefore, is high. The large hospitals generally have liquid or gaseous fuel (Furnace oil/LPG/Gas) based boilers and hot water generation systems.
- *Policy environment*: this is identical to one for hotels – compulsory SWH for new hospitals, concessional interest loan and accelerated depreciation.
- *Other issues*: Unlike hotels, it is not too difficult, barring luxury hospitals, to regulate hot water timing, a positive for SWH installation. SWH-dependent hospital where the system is turned off in summer. Many owners of small/medium hospitals analyze the techno-economics of SWH at great length; the SWH suppliers find it difficult to cope with the demands they raise in terms of time and effort. In several of the large hospitals which are spread over a large area, extensive piping is required for supplying hot water from a central facility and hence the cost involved in piping through a centralized SWH emerges as a major issue.

12. Hostels

The demand for hot water from hostels emanates largely for bathing purpose. There is hot water required for kitchen-cleaning but this is small compared to the bathing demand. The interviews of SWH owners and non-owners, among hostels, highlighted the following.

- Roof availability is almost a non-issue, it is available. However, security and upkeep of SWH installations may demand care in the light of potential student-activity on the terrace.
- It is possible to maximize SWH performance because regulating hot water supply to morning hours is easy.
- It is in summer that hostels have low occupancy. The vacations, thus, do not hurt, demand for hot water.
- From the pay-back period perspective, the business case should assume 250 days of hot water demand per year.
- The common method of water-heating is electricity. SWH, therefore, offers significant scope for cost-saving. The recourse to individual electric heating rods, inefficient and electricity-intensive, is considerable, enhancing further scope for saving.
- Many hostel-owners are sensitive to capital expenditure proposals, notwithstanding recurring saving. This, combined with 250 days/year hot water demand business case, makes a strong financial incentive, necessary to convert potential into actual demand.
- The promotional effort should target both - hostel owners and students.

13. Policy environment (SWH for hotels/guesthouses)

The highlights of the present policy environment are as follows.

1. A municipal corporation order making it compulsory for new hotels to install SWH is in force in many cities. Norms, under the order, for SWH sizing, are lax in most cities. Implementation of mandatory use is weak across cities.
2. A scheme of loans at the concessional interest rate of 5% pa for SWH is being implemented by IREDA but its delivery and utilization are low-key.
3. There is accelerated depreciation provision for commercial hotels/guesthouses. The awareness of the accelerated depreci-

ation provision among owners of modest hotels/guesthouses is low and when informed, the appeal seems unexciting.

14. Challenges still ahead

Some are listed below.

- Many commercial customers are still unaware of the benefits of solar water heating.
- Low natural gas prices are making it hard for SWH to compete in some areas even with incentives.
- Financing mechanisms such as power purchase agreements and renewable energy service contracts are starting to be utilized for solar water heating, but are yet to be widespread.
- The challenges to the solar water hating market are probably more speed bumps than road blocks. The overall trends of increasing and volatile energy prices combined with a rise in environmental responsibility will continue to drive the market in the immediate and long term.

15. Industry analysis

The industry is composed of many different manufacturers of solar water heating components and systems. Some companies operate serving the industrial market, others serve the residential market. There are several companies that make components they sell to different assemblers. There are other companies that make all the components for their systems in-house. Some solar heating systems are complex using computers to make adjustments such as the angle of the collectors based on the sun's position. Others systems are quite basic.

The Indian solar energy sector has been growing rapidly, in the past few years, majorly due to Government's initiatives such as tax exemptions and subsidies. Due to technical potential of 5000 trillion kWh per year and minimum operating cost, solar power is considered the best suited energy source for India. Today the solar power, has an installed capacity of 9.84 MW which is about less than 0.1 percent of the total installed renewable energy of India's currently total installed renewable energy stands at 13,242.41 MW as per MNRE.

India's power sector has a total installed capacity of approximately 146,753 MW of which 54% is coal-based, 25% hydro, 8% is renewable and the balance is the gas and nuclear-based. Power shortages are estimated at about 11% of total energy and 15% of peak capacity requirements which is likely to increase in the coming years. The cost of production range is Rs. 15–20 per unit for the solar energy, which is very high when compared to, Rs. 2–5 per unit for other conventional sources in India.

Typically, for an Indian-make system with single BIS37 – approved flat plate collector of 2 m^2 area, the current market costs are reported to be in the range of 15,000–20,000. If SWHSs are assumed to cover 75–85% of annual hot water demand, then accordingly the cost of hot water decreases in similar ratio. Based on the price of electricity in India, the savings per year for a typical Indian household, through the use of solar water, is in the range of Rs. 4000–7000. Since SWHSs last 15–20 years, it implies that beyond the breakeven period of four years, you get hot water at no cost at all.

16. Survey on solar water heater users

As a result of the survey in a typical city of India among users of solar water heating system would give a breakup somewhat along the following lines [8].

- 100% of the users are in the middle higher to higher income group.
- 70% and above prefer systems with electrical backup while less than 30% opted for standalone solar water heaters.
- More than 80% of the users bought the systems directly from the manufacturer without any third party financing or loan.
- More than 90% of the users found a solar water heating system to be satisfactory, especially in saving fuel costs.
- More than 90% of users would have liked “subsidy” to be available on solar water heating systems. In fact most have purchased the system under subsidy scheme.

17. Conclusions

The solar radiation is available sufficiently over the country. Solar water heating has enormous scope within domestic and industrial sectors of India especially in textile industries where hot water accounts for as much as 70% of the total energy demands.

Resource assessment, technological appropriateness and economic feasibility are the basic requirement of project evaluation. The technology of solar water heaters is not very complex, but it has certainly advanced from simple design to more efficient systems. Innovations have been made broadly in areas such as type of collector i.e., FPC, ETC, CPC; location of the collector (roof, ground and wall mount); and location of the storage tank in relation to the collector, as well as in the method of heat transfer (that is, open-loop or closed-loop with heat exchanger).

Though SWHSs have high initial costs, they payback the cost relatively quickly. In the Indian context, the payback period for a SWHS is less than four years. Given all these facts, there is still a lot that needs to be learnt from across the world. Several countries have experimented with different ways of promoting SWHS. High cost being one of the most important barriers for adoption of SWHS among residential sectors, the barrier can be mitigated by designing appropriate financial mechanisms; there is a likelihood that the demand for these systems will increase, thus, bringing down costs. Since the poor people, particularly the rural people cannot afford this technology; it has to be made affordable by innovative finance instruments and encouragement by the Government bodies and subsidies. The other option is to increase awareness levels about the system and make it readily available to those who can afford it.

Many rural areas still remain the unexploited market for SWHS, especially in the developing world. The need for capacity building in rural areas is a must, and this must be carried forward to the policy-makers so that backward linkages may be established among the users and policymakers. It is necessary to build flexible programs that can adapt to changing markets and accommodate changing perceptions of the users (for instance, building sector policies that mandate SWHS installations for certain types of buildings depending on their footprint and energy consumption may have to be looked afresh) and improve the legal and regulatory environment for encouraging the installation of SWH systems. It is equally important to develop capacity of local manufacturers, distributors, installers, and the financing sector to offer products, delivery models, installation, after-sale, maintenance, and financial services that are conducive to the overall market transformation goals.

Absence of an independent energy policy has prompted the government of India to rely on foreign sources for critical inputs like crude oil, uranium, silicone and take short term initiatives at different periods to address the energy needs of an elite group-comprising mainly of the upper and middle class citizens of urban India, big corporate houses, and large farmers.

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